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ABSTRACT

This position paper of the United Faculty of Florida argues that the state of Florida must become more active in the informational economy of the nation and the world or become a low-wage, semi-colonial area in servitude to centers of "informationalism." The paper begins by examining the economies of America and Florida. Next, the paper discusses high-technology's role in Florida's economy and this is followed by a discussion of how state universities can help to offset what are seen as Florida's disadvantages in drawing high tech firms to operate within its borders. One successful high technology related research center in Orlando, Florida is described as a model for what the state needs to establish in other areas. Next, the need to have greater numbers of Florida students graduating in more rigorous scientific and technical fields is addressed, as well as the state's need for more federal research and development funding. Discussion then turns to the educational role of the University of Florida and the role of Florida State University's Supercomputing Computation Center in advancing the state's needs in high tech development, as well as the development of high technology clusters. Finally, the paper examines the organizing of jobs through these research centers. Contains an 89-item bibliography. (GLR)

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CREATING TECHNOPOLIS FLORIDA.

A POSITION PAPER OF THE UNITED FACULTY OF FLORIDA.

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JOBS THROUGH RESEARCH:

CREATING TECHNOPOLIS FLORIDA.

A POSITION PAPER OF THE UNITED FACULTY OF FLORIDA

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(Amended on basis of discussions since Senate adoption.)

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THE AMERICAN ECONOMY.

The overall competitive position of the United States in the world economy is deteriorating. We have become the world's largest debtor nation and have lost our leading edge in exporting high technology goods. In 1986, for the first time, the United States had a trade deficit in high technology goods, a sector in which we had a $27 billion surplus in 1980. [Howell.] These trends are retarding the growth in personal incomes in the United States and, in the long run, will make us a second-class economic power. Japan, in particular, is coming to own a larger and larger share of our economy as America fails to keep up with the demands of the marketplace.

One major factor in retarding the growth of the United States is that it lacks an economic strategy for competing. Whereas Japan closely integrates governmental decision-making with the needs of industry, America relies upon an eighteenth century notion of the invisible hand of the market as being all-sufficient. The Japanese government and business community ensure that vital new technologies receive the investment and early support which they need to become strong enough to face the world market, while America lets its high technology industries sink or swim on their own—to the extent that they are not tied to the military. [Howell; Borrus.]

New and important research on international competition by Michael E. Porter demonstrates that nations have competitive advantage based on local clusters of closely related, rival firms which encourage each other to innovate in a continuous fashion. Numerous firms exist in these competitive clusters. Government policy needs to foster these clusters, but to steer clear either of over-regulation or of not providing the necessary support system. Government is crucial, but it must operate with a light and deft hand. [Porter.]

World technological change is taking place at an increasingly rapid rate. New products are more and more sensitive to developments at the frontier of pure scientific research. A "scientification" of technology is taking place. The number of Ph.D. scientists and engineers doing research for industry doubled over the 1980s. [Rosenfeld.] Also, technology is becoming increasingly complex and requires the cooperation of people from a variety of highly specialized scientific and technological backgrounds. Companies must forge close linkages with universities if they are to be competitive. [Stankiewicz.]

We are entering an age of "informationalism", in which the key to technological development is the accumulation of knowledge. Information flows are at the center of the economy, just as the flow of food was once central to the agricultural economy and the flow of mass-produced goods was once central to the industrial economy. Microelectronics is the key technology today, particularly in the Florida high-tech economy. This is based on information processing. Information of a very high order is required to keep abreast of the competition in microelectronics, while the goal of microelectronics is to produce

machines which use information as a raw material and emit information as the final product. A society based on information is characterized by rapid change, constant adaptation, and a minimal distance between the economy and the other social institutions, including government and education. [Castells.]

No way exists to hold on to an agricultural and industrial economy with their greater degree of stability. Any region which does not fully participate in the informational economy is doomed to become a low-wage, semi-colonial area in servitude to the centers of informationalism. The only sensible plan is to move into the information economy with our eyes open, seeking to minimize the negative impact of these changes, while upgrading our position in the national and international division of labor.

High-technology industrial growth does not inherently create unemployment, but can foster productivity and economic growth. "... (I)t contributes to higher demand, investment, and output, ultimately expanding employment, mainly outside the high-technology sector of the economy." [Castells.]

FLORIDA'S ECONOMY TODAY.

Florida is a rapidly growing state, but its growth is not necessarily "quality" growth. As noted in **Cornerstone—Foundations for Economic Leadership**, a 1989 report funded by 100 Florida companies and organizations, Florida is getting bigger, but this does not automatically mean better. For quality growth to occur, average incomes would have to rise. New jobs should be more skilled, autonomous and lucrative than the old jobs. The infrastructure of roads, utilities, and public amenities would

have to improve. And the quality of the environment should be restored through less pollution, more protected wilderness areas, and a return of abundant wildlife. For Florida to be getting better rather than worse, our crime rate must decrease, our schools become more effective, and our families grow stronger. The rate of serious drug and alcohol abuse must decline.

But none of this is happening. Florida is growing, but in the most important indicators our quality of life is eroding. Some people are growing wealthy from growth, but most Floridians are suffering from it. The answer does not lie in stopping growth. The urge of retirees to come to Florida cannot and should not be halted. The shift of jobs from the Frost Belt to the Sun Belt is not going to stop. Growth is going to continue, but it is up to us to make this beneficial to the people of the state.

Quality growth, as the **Cornerstone** study pointed out, requires Florida to turn away from its "cheap labor" status and become a "high skill, high pay" state. Florida needs to build a "world-competitive" economy. We must build up the industries of the future and out-compete not only the traditional American manufacturing states, but also such formidable overseas competitors as Japan and Germany. At present, the real gross state product per employee is 13% below the national average. Florida workers add less than average value because they are less educated and less skilled than workers nationally. The result is a per capita wage and salary income for Florida workers well below national averages. Also, the real standard of living of Florida workers is growing at less than the national average. [FT, July, 1989.]

Basically, Florida has moved from being a low-wage economy based on agriculture, timber, fishing and phosphate mining to a low-wage economy based on services to retirees, real estate, tourism, and a modicum of manufacturing. The average annual pay for Florida residents in 1986 was $17,679, compared to a nation-wide average of $19,966. [FSA-88: Abbreviations given in Bibliography below.]

Florida's Gross State Product (GSP) per employee is in the lowest 20% of states and 13% below the national average. By sector, state government workers, farmers, and miners in Florida have productivity levels higher than national averages, but workers in construction, manufacturing and services have productivity levels strongly below the national average. And the mix of activities in Florida is toward low-productivity sectors, especially services and retail trade which have a productivity only half that of other sectors. Florida has a larger share of its GSP in retail trade than any other state.
[FT, December, 1988.]

Services are expanding as a percentage of all jobs in Florida. Services represent 31% of all jobs in Florida—compared to 22% nationally. Moreover, 38% of all new jobs created in Florida from 1983 to 1987 were in services. In 1986, the average Florida manufacturing job paid $21,472. The average services job paid $16,844. And the average job in retail trade paid $11,288. [FSA-88.] Between 1983 and 1987 service job salaries increased only half as fast as the average . [FT, May, 1989.] In 1988, Florida was the sixteenth highest state in per capita disposable income (income after taxes). [FOF.] However, this income was not equitably distributed. Wealthy retirees and

rentiers from other states and countries offset many low-income Floridians of working age. Whereas for the United States as a whole, only $2805 of the per capita average income of $16,503 came from dividends, interest and rent, in Florida these sources amounted to $4065 of the average per capita income of $16,497. In Collier, Sarasota, Martin, Palm Beach and Indian River counties, dividends, interest and rent amounted to over $7000 in the average per capita income. Incomes in those counties were also higher than the statewide average, ranging from $19,000 to $23,000. [FSA-90.] We view it as very important that Florida not become polarized between a wealthy elite and an impoverished mass. Florida should not become a rentier economy, living off of wealth produced elsewhere. This is inherently unstable and does not provide well-paying jobs for ordinary Floridians.

Florida added many new jobs in manufacturing over the decade of the 1980s, at a time when the number of such jobs in the nation as a whole was declining. From 1980 to 1989, the number of manufacturing jobs in Florida increased by 94,000, but the number of such jobs in the country fell by 900,000. Manufacturing employment in Florida increased 18.8% over the 1980s, while it declined nationally by 5.3%. [FT, April, 1990.] However, Florida remains far behind other large states in the percentage of personal income coming from manufacturing, with only 11.2% in 1988, compared to 18.3% in California, 28.2% in North Carolina, 16.2% in Texas, and 20.3% for the United States as a whole. [FSA-90.]

The mixed picture of manufacturing in Florida is demonstrated by the fact that the percentage of total employment in manufacturing declined from 13.1% in 1980 to 10.8% in 1989, but the

share of the total output of Florida's economy coming from manufacturing increased from 10.8% in 1980 to 13.0% in 1989, almost precisely the reverse pattern. [FT, April, 1990.] In 1986 only 517,000 were employed in Florida in manufacturing (with 150,000 in high technology manufacturing), as opposed to 1.2 million in trade, another 1.2 million in services and 700,000 in government. [FSA-88; Eisinger.]

Many of the most lucrative jobs for people without a college education are in manufacturing. Manufacturing workers in Orlando average $28,000 a year. Even the $22,000 averaged by manufacturing workers in Pinellas County is far above average service sector salaries. [FT, June, 1989.] As of October, 1990, average weekly earnings for production workers in Florida were $364, with a range from $299 in Miami to $532 in Pensacola. [**Employment and Earnings**, December, 1990.]

Unemployment is now higher in Florida than for the nation as a whole. In October, 1990, the Florida unemployment rate was 6.2%, ranging from 7.0% in West Palm Beach to 5.7% in Orlando. [E&E, December, 1990.] Between June, 1989, and June, 1990, Florida's unemployment rate increased by 8.2%, while the national rate fell by 3.6%. [FT, September, 1990.] Florida is not keeping up with its earlier pace of job creation. Earlier, Florida created 10% of all the new jobs created in the United States. Currently it is only 6.5%. [**FT**, December, 1989.] Florida's unemployment rate has shot ahead of some Rust Belt states.

A logical answer to Florida's need for high-wage, high-skill jobs would be to expand high technology industry in the state. Such jobs could help employ the unemployed and give work to minorities, particularly if state high-tech programs are estab-

lished with these considerations in mind. Some 2/3 of the total growth in manufacturing employment in Florida came in high technology and military-related manufacturing from 1980 to 1986. And the total value of manufacturing as a share in Gross State Product grew by 7.5% per year in Florida from 1980 to 1986, faster than any other sector of the economy. Manufacturing employment grew by 2.3% per year. [FT, December, 1988.]

Florida is rapidly increasing the number of workers in high-tech industry. While it was the ninth largest state in the country in high-tech employment in 1980, by 1987 it had become the sixth largest with 155,497 employed. This was a 33% increase in employment and no other state in the top ten had such a large percentage increase. By comparison, Florida was only the fourteenth largest state in total manufacturing employment in 1988, up from seventeeth in 1978. Florida had the most new industrial plants built in 1988 of any state and it was the second highest state in the number of new business incorporations. [FOF.]

A disproportionate share of Florida's high-tech jobs are in manufacturing for the military. Today, military cutbacks are causing the disappearance of tens of thousands of well-paying manufacturing jobs. The value of prime military contracts in Florida was down 8.1% in 1988 over 1987, from $5.8 billion to $5.1 billion. And Florida's share of national prime military spending was down from 4.9% in 1987 to 4.2% in 1988. Layoffs of hundreds of workers each took place at numerous military contractors around the state in 1989 and 1990, including: Honeywell, E-Systems, Unisys and Hercules in Pinellas County; Martin Marietta in Orlando and Ocala; and Pratt and Whitney in Palm Beach. [FTYB-89, 90.]

Even though Florida was the fourth largest state in population, it was only the seventh largest state in military contracts in 1987. [FOF.] And while Florida in 1982 had 4.2% of all American employees in military manufacturing, it produced only 3.0% of the value of all military manufacturing shipments. [Castells.] In other words, Florida involvement in military manufacturing was at the low end of the scale in terms of worker skill and worker pay. Florida got the routine assembly jobs to a greater extent, while other states got the R&D work and the highly skilled blue collar jobs. In pure economic terms, counting on military spending is not wise for Florida's future, but even more than this the United Faculty of Florida does not wish to base our state's livelihood on creating weapons of mass destruction.

Just as the answer does not lie in manufacturing for the military, so too the answer does not lie in attracting branch plants of large corporations. Such employment is generally low-wage assembly work, rather than well-paid corporate headquarters jobs or research and development employment or skilled blue-collar work. Too much of Florida's high-tech industry today consists of branch plants of large corporations, and not enough is in the form of indigenous companies.

Of Florida's 155,000 employed in high-tech industry, 66,000 were employed in firms with over 1000 workers and 18,000 in firms with 500 to 999 workers. [CBP-88.] Large high-tech plants have been a very unstable part of Florida's economy over the 1980s. Such plants tend to disappear, either the company going out of business or by being closed by their parent firm. This is not such a danger when a whole constellation of plants of various sizes exists in a locality.

Depending on national firms means subjecting Florida to an even bumpier rollercoaster ride than relying on clusters of local high-tech firms. For instance, IBM shut down its PC manufacturing operations in Boca Raton in 1988 and laid off 1600 people. Many of them are still unemployed. [Koenig.] Within the past twelve months (December, 1989 to December, 1990) high tech employment in Florida has increased by only 0.2%, as opposed to a national increase of 3.3%. [Koenig.] Dependence on large firms and military contracts is now leading to stagnation in Florida's high-tech industry.

Due to its location and lack of raw materials, Florida is not likely to become a center for traditional manufacturing or heavy industry. High technology products which embody high value per unit of weight are more likely to be manufactured in Florida. High tech manufacturing can become even more important in the future for Florida if we have strong, effective state policies to promote civilian industry which can overcome the decline in military contracts in the future and which can convince the high tech firms already located in Florida that it is worthwhile for them to remain here.

Things are not likely to improve in the future without a major change in state policy. Florida's problems with infrastructure and education have caught up with it. The path on which Florida is travelling leads in the direction of low-quality growth. High-tech industry will not locate in Florida just because of our warm weather and sandy beaches. Quality of life improves when high tech moves in and brings with it high-wage employment and the resources to enhance the educational and cultural potentialities of a region. [Castells.] Quality of life can improve as the result of high-tech growth.

THE ROLE OF HIGH-TECH INDUSTRY.

We are interested in enhancing the role of high-technology industry in Florida's economy. The criticism can be made that the high technology sector does not include a high proportion of well-paying blue collar jobs. This is true, but we are not aware of any alternative industry which might provide large numbers of such jobs which could as readily be created in Florida. Many well-paying jobs do exist in high tech, particularly in professional and managerial positions, but also in skilled blue collar and technician work. Our expectation would be that the basic assembly operations would not necessarily stay in Florida, but would be relocated to cheaper labor countries in the Third World after a time. However, a certain amount of assembly work would take place in Florida, particularly in new start-up firms. The impact of high tech, then, should be to provide increased numbers of well-paying, blue-collar jobs, as well as many opportunities for the children of blue-collar workers to attain technical training or university educations and move up to technical, managerial and professional jobs.

Another criticism of high tech employment is that it is unstable. We freely admit this, particularly in the early stages of an industry's development. Part of the price which must be paid for participation in high technology industry is a certain instability in employment. The alternative to this is far worse: being shut out of the most rapidly growing and profitable sectors of industry and accepting for American labor a permanently low-wage position in the international division of labor. Further-

more, no guarantee of job stability exists in the low-wage sectors. If we want to compete in such sectors, Third World countries can always underbid us. Setting up a high ring of protectionist walls around the country is not a satisfactory answer. We cannot really wall ourselves off from the world economy, and even if we could, doing so would only serve to impoverish American workers in the long run.

Silicon Valley and the Massachusetts Miracle have been through some hard times since the mid-1980s. However, thousands of people are still employed in high tech in those areas who would not have such good jobs if this industrial sector had never existed there. In Silicon Valley alone, 15,000 millionaires and two billionaires have been created by the electronics industry. [Larsen and Rogers.]

Unlike the Silicon Valley and Route 128, Florida would be attempting to develop a wide variety of high tech industries in its five emerging clusters. Our state's economy would not be captive to semiconductors or minicomputers in the fashion of Silicon Valley and Route 128. We could expect cycles of boom and bust in the initial stages of growth of each technopolis, but they would not be closely in sync with each other and so the state's pattern of growth would even out. Also, high tech in Florida would serve as a supplement to traditional economic activities in tourism, retirement services, and agriculture, rather than as a total replacement for these activities. High tech would provide greater balance and consistency to the Florida economy.

The United States is in danger of losing its competitive edge in high technology industry for several reasons: continuous

investment of large amounts of capital is required in the rapid, early stages of growth of a high tech industry, and capital costs are too high and sources too restrictive in the US; too much research in the US has been devoted to military objectives which do not result in spinoffs to civilian industry; governments at all levels give too little support for high tech R&D; and the tradition of pure research in US universities has hindered their involvement with the more applied kind of research relevant to high tech companies.

The same problems which the United States manifests in its high tech competitiveness on a national scale, Florida manifests in its relations with other states. An outmoded notion of pure market self-sufficiency in high tech industry (although not in agriculture) prevails here which drastically hinders us from effective competition. Although Florida has made a promising beginning in funding high tech related research and in establishing a major university research center dealing with electro-optics and lasers, the level of support for such activities statewide in Florida has not yet reached that in other major states. The industries of the future still do not have as much political clout as the industries of the past in Florida.

STATE UNIVERSITIES AND HIGH-TECH INDUSTRY.

As part of a balanced economy, Florida needs to expand in sectors characterized by high salaries and by high multiplier effects on local economic activity. Multipliers indicate how many times a dollar spent in a particular industry turns over in the local economy. Some new jobs have the effect of creating other new jobs, while other new jobs have relatively little impact. "Quality growth" areas with high multipliers include: national corporate headquarters (and related business services provided by outside firms, such as lawyers, banks, and advertising agencies); research and development for civilian industrial products; and manufacturing, particularly high technology manufacturing. If a service sector job—due to its lack of impact on other economic sectors—has a multiplier almost as low as one, manufacturing jobs have multipliers of two, R&D jobs have multipliers around two and a half, and corporate headquarters jobs have multipliers of three. [Noyelle.]

The answer in creating quality growth does not mainly lie in attracting existing firms to Florida. The non-native high tech firms which have put some of their operations in Florida have mostly chosen to locate manufacturing plants here to take advantage of our low wages. In spite of notable exceptions, such as IBM, Harris and Martin Marietta, outside firms have done little R&D here. [Roberts.]

In order to be successful, the state is going to have to become entrepreneurial again. The state of Florida has always been heavily involved in the promotion of the local economy, but this has mostly been the furtherance of agriculture, forestry,

fishing, and tourism. However, Florida missed her opportunity after the Second World War to continue the industrial progress made during the war. As one scholar stated, "If the state of Florida had acted to upgrade two or three state universities after World War II, all the ingredients would have been assembled for the kind of development the Research Triangle has experienced in terms of the growth of research activities." [Whittington.]

Now, a very active effort will be required to develop whole industries which do not as yet even exist in Florida. The state can no longer passively mirror the existing economic actors but must take the initiative in helping to create a fundamentally new, high technology economy of the future. Other states are already far ahead of us in creating a new entrepreneurial state. Florida must either catch up or else face a future as a second class economy. [Eisinger.]

The factors governing location of high tech firms are (by rank order of importance):

1. Availability of skilled labor;
2. Labor costs;
3. State and local taxes;
4. Academic institutions;
5. Local cost of living.

[Robert Premus, "Attracting High-Tech Industry and Jobs: An Assessment of State Practices," in Walzer.]

Skilled labor includes scientists, engineers, and technicians, as well as skilled blue collar workers. Compared to states with which we are competing, Florida does not employ a high proportion of engineers. Only 1.1% of all employed people in Florida in 1980 were engineers, but in California 2.0% were

engineers. Massachusetts' employed population included 1.9% engineers, Texas' 1.5%, and so forth. Technicians and technologists amounted to only 2.0% of Florida's employed population, but 2.5% in California, 2.4% in Massachusetts, and 2.3% in Texas. And highly skilled blue collar workers in precision production occupations comprised only 3.2% of Florida's employed population, compared to 4.7% in Massachusetts and 4.4% in both California and Texas. Adding all three categories together (engineers, technicians and technologists, and precision production workers) to get a total for technical workers, Florida had only 6.3% of its employed population so occupied, compared to 9.1% in Massachusetts, 8.9% in California, and 8.2% in Texas. [John C. Hoy, "Higher Skills and the New England Economy," in Lampe.] These figures amply demonstrate Florida's lack of attractiveness to high tech firms looking for a place to do research and development or highly skilled manufacturing.

Both the availability of skilled labor and the fourth motive for high tech location, academic institutions, are closely related to higher education. "Intellectual infrastructure," a concept elaborated by William D. Stotesberry of the Microelectronics and Computer Technology Corporation in Austin, Texas, encompasses factors central to the development of local high tech industry. Intellectual infrastructure includes:

1. K-12 education;
2. undergraduate education;
3. graduate education;
4. research facilities in local universities;
5. research facilities in corporate and government labs;
6. computing facilities; and

7. research libraries.

In every respect, one could say that Florida's intellectual infrastructure is underdeveloped.

As Michael Porter states in **The Competitive Advantage of Nations**, in discussing the factors which lead to industrial strength today, "**Advanced factors** include...highly educated personnel such as graduate engineers and computer scientists, and university research institutes in sophisticated disciplines....Advanced factors are now the most significant ones for competitive advantage. They are necessary to achieve higher-order competitive advantages such as differentiated products and proprietary production technology. They are scarcer because their development demands large and often sustained investments in both human and physical capital. The institutions required to create truly advanced factors (such as educational programs) themselves require sophisticated human resources and/or technology." [Page 77.] He also states, "Government policy at the state and local level has an important role to play in shaping national advantage." [Page 29.]

According to **Strengthening The Linkages: Education and Economic Development**, a November, 1987, report by the Florida Education and Industry Coalition of the Florida Chamber, "Florida receives less than 50% of the national average per capita funds for federal and industrial research." Other indicators of the same lag include the fact that Florida, the fourth largest state in the country by population, is not among to top 15 states in the country in receipt of federal Small Business Innovation Research grants. These are given to firms for high risk research. Only states with more fully developed university

resources are successful in these grants. Only 8% of proposals by Florida firms for these research grants are successful, as compared to 21% for Massachusetts firms. [Miller.]

In order to develop our own companies, Florida universities must be doing research in areas related to high tech and this research must be carried out at world-class levels. The historical development of science-based industries demonstrates that at their initial stages, they relied heavily on university research, while developing their own corporate research apparatuses at later stages in development. [Stankiewicz.]

Important steps have been taken in Florida over the past six years to lay the basis for university research in high tech related areas. University faculty members and administrators, especially deans of colleges of engineering, high tech industrialists, and state officials have put in a great deal of thoughtful effort to help Florida move toward becoming competitive in this field. The establishment of the Florida High Technology and Industry Council (FHTIC) in 1984 was a major step forward. The Applied Research Grants of the FHTIC go to university researchers for topics relevant to Florida firms. These grants amount to $7 million a year now and provide an important stimulus for linkages between the universities and the private sector. Counting the university research centers which already exist, the Applied Research Grants and other efforts, Florida is presently spending a total of $26 million per year in high tech related activities. Our proposal would greatly increase this sum.

Some people in universities and high-tech industry would prefer not to establish or expand Jobs Through Research Centers directly, but rather focus on an expansion of the grants through

the FHTIC. We believe that the grants are constructive in promoting the research agenda of existing Florida firms and enhancing the research activities of existing university centers. However, this funding does little to promote the establishment of new firms, and it does not create centers in universities which currently lack them.

Some people in industry worry that state funding for centers would simply create research driven by academic interests, rather than by the needs of the Florida economy. We believe that this concern can be addressed by creating tightly focused centers. The drafting of the legislation creating the Jobs Through Research Centers should be a collaborative process involving both the universities and high-tech companies. Oversight mechanisms should be established at the statewide and university levels to ensure that these centers in fact carried out a narrowly focused research agenda which enhanced the local economy at the same time that it carried out basic research of national and international significance. A properly funded and managed effort should contribute both to the concerns for the universities for prestige in basic research and to the concerns of industry for local impact.

One successful high technology related research center has been established at the University of Central Florida in Orlando, the site of a Martin-Marietta plant employing 13,000. [FCP-89.] The Center for Research on Electro-Optics and Lasers (CREOL) at UCF is a model for the kind of research center which needs to be established at other locations around the state where clusters of high tech firms are emerging in specific industries. Some thirty laser companies operate in the Orlando area. This is the third-largest center for employment in the laser industry in the United

States, after Silicon Valley in California and Route 128 around Boston. By the year 2000, Florida is projected to have 21,000 people working in the laser industry and it is projected to be generating revenues of $2.3 billion. CREOL is now in its third year of operations with a budget of $7 million per year and around 100 employees, including some of the top national researchers in fields such as free electron lasers, thin film coating and crystal growing. A new building is being planned and up-to-date equipment has been purchased.

CREOL is partly responsible for the fact that Orlando's laser industry is the healthiest branch of high-tech in Florida. This is a cluster of start-up, competitive, independent firms around the giant mother firm, Martin-Marietta. According to Gabriel Rosica, Orlando has achieved "critical mass" in the laser industry, i.e., there are enough researchers and competitive firms in the area so that self-sustained growth will continue in the future. [Koenig.]

CREOL helps private firms take advantage of research breakthroughs in the university. CREOL is also educating graduate students who will someday form their own startup companies. However, Orlando's computer industry began with Martin Marietta and has always been closely linked with military spending. Cutbacks in this could hurt their prospects. Some of these companies are diversifying into civilian applications of lasers, including medical and optical uses. [FTYB-90.] Continued strong state commitment is essential to keep this laser industry growing. CREOL's research efforts are well underway, with a strongly financed program and an able staff. For the next several years, CREOL should probably devote itself to absorbing the growth of

the recent past and to getting its research projects well underway. Only marginal funding increases from the state are necessary to optimize CREOL's contribution to the Orlando economy. Our proposal does not envision a major impact on CREOL funding, but rather an emulation of CREOL at four other sites in the state. CREOL is our model.

The new magnetics research laboratory at Florida State University marks a qualitative step forward in the willingness of Florida to fund scientific research. The state will put up about $50 million and the federal government will put up another $50 million for this center. Although **Enterprise Florida**, the study commissioned by the Florida Chamber, does not foresee a high-tech future for the Tallahassee area, we hold open the possibility that the magnetics research lab will have such a major impact that spinoff companies will result. The state should take the necessary steps to ensure that technology transfer to new high-tech companies does take place in association with this center. The magnetics research lab is not part of our plan, however, since it has come about through an entirely distinct process and since its main function will be as a national research center into basic scientific questions, rather than as a high-tech related research center.

The most logical plan for Florida statewide seems to be to concentrate high tech related research in urban centers where the beginnings of high tech industrial clusters already exist, while UF and FSU should be given statewide missions of supporting high tech industry through educational programs and the Supercomputing Computation Institute.

Other states are putting massive funding into their universities in order to promote local high technology growth, and

spending in Florida has been only a third as great as the average of that in the five top states (Texas, Pennsylvania, Ohio, Indiana, and Connecticut). In all, the various states spent $700 million in technology initiatives in 1986, much of this through their universities. [Slaughter.]

California in 1981 appropriated $22 million to aid the electronics industry, including a $2.6 million microelectronics research facility at Berkeley. [Whittington.] And after 1983 California increased the budgets of its state universities by 1/3 to assist high tech industry in the state. Texas in 1985 passed a $35 million fund for high tech related research in state universities.

Arizona spent $50 million to make Arizona State University an engineering center of excellence, with an emphasis on microelectronics and computer science. [Eisinger; Rosenfeld; Whittington.] A further $40 was invested by the university and a nonprofit corporation in land and infrastructure for a research park in Phoenix. [Wigand.]

Ohio has established a series of research centers linked to local industry throughout the state. This Thomas Edison Program began in 1983 with a state appropriation of $33 million and private contributions of $80. [Rees, 1990.] In Michigan, the state built a $17 million Industrial Technology Institute to develop and implement computer-integrated manufacturing systems. [Eisinger; Whittington.] North Carolina spent $24 million to set up a Microelectronics Center in the Research Triangle beginning in 1981. [Whittington.]

New York State loaned $30 million to the Rensselaer Polytechnic Institute to set up a Center for Industrial Innovation as an

incubator for high-tech start-ups. Dozens of new enterprises were spawned at the incubator from 1980-85. Rent is graduated, and younger companies pay less. They use RPI's computers, libraries, data bases, workshops, labs, testing equipment, and faculty consultants. The state is to share in patent royalties from firms developed at the center and owns 2% of company equity. Only companies which are high-tech, market-oriented and interested in interacting with RPI's faculty and students are allowed into the incubation center. The director of the incubator is a former banker who links start-up companies to bankers and venture capitalists. By October, 1986, fifteen companies had successfully graduated from the incubator and were operating out of other quarters, some of them in RPI's Technology Park. Some 400 full and part-time jobs had been created by companies associated with the incubation center. The Technology Park housed both start-ups and branches of larger corporations. [Abeti; Vaughn.]

New Jersey has established seven advanced technology centers, with state funding of $2 to $3 million per year for each and additional funding from private corporations. [Clarke.]

Pennsylvania's Ben Franklin Partnership was initiated by Republican Governor Dick Thornburgh (now United States Attorney General) in 1982. This Partnership set up four Advanced Technology Centers in which research universities, private businesses, labor and economic development groups cooperate. The Partnership provides funding for research and development and product development projects. Between 1983 and 1986, the state has invested $77 million in high tech projects through the Partnership which has leveraged $281 million in matching funding from the other partners. The various Centers emphasize robotics, high

tech materials, metals and biomedical research. The Centers also provide management assistance to new companies and run incubators. They also train workers for the new jobs created. About 1000 new jobs have been created and 1500 additional jobs retained as the result of the activities of the Partnership. [Clarke; Miller; Eisinger.]

The Texas legislature funded the Advanced Technology and Research Program with $70 million in 1987. The University of Texas (UT) in 1987 had 18 research centers in engineering with a total funding base of $28 million. The largest was in electromechanics and spent $11 million per year. UT also had $21 million funding in science research. Texas has made a major effort to transform the Austin-San Antonio corridor to a high-tech center. Of 103 small and medium high-tech companies in Austin in 1986, exactly 53 originated directly or indirectly from the University of Texas. Founders of these companies included UT students, graduates, faculty and other employees. Locating in Austin also were MCC and Sematech, national consortia involving many corporations and the federal government which do research on basic problems of computers and semiconductors. Many branch plants of national corporations have located in Austin, so that it is not a perfect example of what we are seeking to do in Florida. [Castells; Gibson; Smilor, "Austin".]

Our main foreign competitor, Japan, is attempting to create 28 technopoleis which unite industrial research, education and production away from the main cities of today. Tsukuba Science City, near Tokyo, was the first such technopolis. Some 46 national research and educational agencies located there after it was begun in 1958, along with some private research institutes.

Of the total national R&D budget, 50% is spent in Tsukuba. However, this is not a location for manufacturing, while the other technopoleis around Japan integrate research and manufacturing. Many of them will have a specific high tech industrial focus, such as fermentation, interferon, semiconductors, mechanotronics, electronics, ceramics, and bioresists. [Castells; Onda; Tatsuno.]

Although Florida has invested in high technology-related research in universities and has developed research parks attached to universities, we have not yet, aside from CREOL, begun to develop such projects on the scale of other states. The funding for a truly competitive effort has been absent.

SCIENCE AND ENGINEERING GRADUATE EDUCATION.

The pattern over the 1980s for the number of fulltime graduate students in science and engineering was as follows:

TABLE 1: FULLTIME GRADUATE STUDENTS IN SCIENCE AND ENGINEERING.

	1980		1988	
	ABS	% NATL	ABS	% NATL
USA	249	100	289	100
FL	5.9	2.4	7.5	2.6
TEX	14	5.6	18	6.2
CAL	36	14.5	40	13.8
NC	6.0	2.4	7.4	2.6
MASS	13	5.2	15	5.2

SOURCES: ASE-80, ASE-88.

In 1988, the University of Florida was 24th in the nation among all universities in graduate science and engineering

enrollment, up from 28 in 1983. USF was number 78, up from 123; FSU 108, down from 78; UM 117, up from 124; UCF 130, up from 163; Florida Institute of Technology in Brevard 138, down from 27; FIU 181, up from 544; FAU 205, up from 210; and FAMU 287, up from 489. By the number of women grad students in science and engineering, UF was only 32nd. Of the other schools, FSU, UCF, FIT, and FAU scored lower in female enrollments than in overall enrollments, while USF, UM, FIU, and FAMU scored higher. By the number of minority grad students in sciences and engineering, UF was only 40th. Compared to overall rankings, USF, FSU, FIT, and FAU were lower, while UM, FIU, UCF, and FAMU were higher. [ASE-88.] Valuable state resources are being wasted in the failure of many institutions to enroll sufficient numbers of female and minority graduate students in sciences and engineering. This should be a legislative priority. More special funding can be made available for attracting female and minority grad students. And direct orders can be given to the delinquent institutions to take steps to recruit and retain such students.

The major disciplines of graduating students in Florida public universities differ markedly from national averages. As a percentage of all degrees, Florida graduates a much lower percentage of students in the most rigorous scientific and technical fields. In physical science, Florida graduates 22% fewer students at the baccalaureate level, 39% at the master's level, and 38% at the doctoral level. In life science, there are 28% fewer at the baccalaureate level, 41% at the master's, and 37% at the doctoral. In computer science, Florida graduates 35% more than the national average at the bachelor's level, but 9% less at the master's and 50% less at the doctoral level. [SHEP.]

In engineering, the pattern is the same. Florida in 1985, when it was the fifth largest state by population, was only the tenth state in terms of the number of engineering baccalaureates granted, sixteenth in engineering master's degrees, and fifteenth in engineering doctorates. [Gonzalez.] In terms of the total employment of registered engineers, Florida in 1988 was the sixth largest state with 21,000. This had increased 81% from 1978-88, by far the fastest percentage increase in the ten largest states for employment of engineers. The closest state to us was Texas, where the increase was only 41%. [FOF] The gap between being the tenth largest state in the number of engineering baccalaureates granted and the sixth largest state in the number of engineers employed is, of course, made up by importing engineers who were educated in other states. By default, we are allowing non-Floridians to take a major share of the lucrative jobs as engineers. Florida has a definite shortage of hard science degrees at every level, but an even more pronounced shortage of the more scientific, quantitative and technical degrees at the master's and doctoral levels.

One revealing indicator of Florida's needs is the number of full-time scientists and engineers employed at public doctorate-granting institutions in January, 1985. Florida had 4345, making it only the eighth largest state in such employment. [SUS Excellence-86.] Florida lags substantially behind Texas and North Carolina which are states coming from behind to develop their high technology industry. If Florida wishes to emulate their success in attracting and retaining high technology industry, their practices in the employment of state university scientists and engineers should be studied.

TABLE 2: EMPLOYMENT OF SCIENTISTS AND ENGINEERS IN PUBLIC UNIVERSITIES, JANUARY 1985.

	SCIENTISTS	TOTAL POP (MILLIONS)	SCIENTISTS PER 100,000 POP
CALIFORNIA	11,649	23.7	49
TEXAS	11,453	14.2	80
OHIO	7,384	10.8	68
MICHIGAN	6,752	9.3	72
NEW YORK	5,342	17.6	30
PENNSYLVANIA	5,329	11.9	45
ILLINOIS	5,037	11.4	44
FLORIDA	4,345	9.7	44

SOURCES: SCIENTISTS: SUS EXCELLENCE-86; POPULATION, **WORLD ALMANAC, 1989;** RATIO, OUR CALCULATION.

The most important students for Florida's future as a high technology state are majors in the appropriate engineering specialties, particularly electrical engineering and computer science. Florida in 1988 had 2946 graduate students in engineering generally, of whom 998 were in electrical engineering. Of these, 279 were at USF, 249 at UF, 238 at FIT, 117 at FAU, 52 at UM, 39 at FIU, and 24 at FSU. And 1060 graduate students were in computer science, including 271 at FIT, 161 at UCF, 149 at Nova, 135 at FSU, 118 UWF, 113 UF, 89 UM and 40 FIU. [ASE-88.] Measures must be taken to attract bright students to electrical engineering and computer science. We need to establish a healthy flow of undergraduate students in these fields, but the key to high tech spinoffs from university activities lies in graduate students who start their own companies. We must do more to encourage this by giving special scholarships to bright engineer-

ing students. We need to decide how many engineering graduates we want to educate and then offer support for students at a level sufficient to attract enough. The best graduate students should be attracted from the national pool. With graduate students, the important thing in their ultimate location decision is where they receive their doctorates, rather than where they originally come from. In many cases, graduate students will remain close to the university after receiving their degree if suitable opportunities are available locally. [Van Horn.]

RESEARCH FUNDING.

Even though Florida is the fourth largest state, the Florida State University System was only the seventh highest university system in the country in federal R&D funding in 1988—not mentioning the fact that some states ran two or more separate university systems. Ahead of Florida in the rankings were: the University of California System; the University of Texas System; Columbia University System; the University of Wisconsin System; the University of Illinois System; and the University of North Carolina System. [FSU-90.]

Nationally in 1983, R&D was concentrated in only 200 universities. MIT received more federal R&D money than universities 200 to 500 on the list ranked by the amount of funding. The 200th university spent $4 million per year on R&D. [Fusfeld.] Florida has the task of making all of its urban universities into top 200 institutions. Merely winning a larger share of federal R&D funding would be very important for Florida, since the U.S. government spent $5 billion on R&D in universities in 1983. Pri-

vate industry spent another $400 million. [Fusfeld.] Receiving a larger share of this federal-industry R&D funding could be a significant boost to the Florida economy. Many well-paying jobs will be created in university laboratories. For every scientist or engineer in R&D work, there are also 1 2/3 technicians, clerks, and others assisting in the effort. [Fusfeld.] But the key pay-off will be in the spin-off companies which this research produces.

R&D funding patterns at doctoral granting institutions were as follows:

TABLE 3: R&D FUNDING AT DOCTORAL-GRANTING INSTITUTIONS.

(MILLIONS OF $)	1980		1987	
	ABS	% NATL	ABS	% NATL
TOTAL, ALL SOURCES				
USA	5961	100	11,931	100
FLORIDA	133	2.2	252	2.1
FEDERAL FUNDING				
USA	4029	100	7230	100
FLORIDA	69	1.7	129	1.8

SOURCE: ASEF-87.

Given that Florida has almost 5% of the national population, these figures are less than half of what they properly should be. In federal funding of science and engineering at Florida's universities, there is too much dependence on military funding from the DoD, and not enough funding for civilian research. Overall, Florida universities and colleges received 2.3% of all federal spending on academic science and engineering in FY88, but this

ranged from 3.3% of all military spending to only 1.7% of all NASA spending and 1.8% of all National Science Foundation spending. [FSU-90.] Given Florida's location as the site of Kennedy Space Center, the low level of NASA spending is disconcerting. We need to build a much more elaborate UCF presence in Brevard County and go after large increases in NASA funding.

Florida should set as a target the winning of 5% of all of Federal science and engineering spending in colleges and universities. This is what we have coming as a share of our federal tax dollars. And there would be nothing wrong with getting more than our share later on after we have achieved our first goal.

TABLE 4: R&D FUNDING AT DOCTORAL INSTITUTIONS, FY87, BY SOURCE OF FUNDS.

	STATE/LOCAL		INDUSTRY		UNIVERSITY	
	ABS	% NATL	ABS	% NATL	ABS	% NATL
USA	1003	100	764	100	2110	100
FLORIDA	13	1.3	21	2.7	72	3.4

SOURCE: ASEF-87.

Compared to overall and federal R&D spending in Florida universities, state and local sources are low and industrial and university sources are high. Florida's universities are making a strenuous effort to compensate for the absence of state funding out of their own resources. However, such an effort necessarily detracts from the teaching role of the universities. The key source of weakness of R&D funding in Florida universities is the absence of larger state funding.

If one considers how many universities in Florida are among the top 100 in the United States in research and development funding, it is apparent that several other states with smaller

populations are better served. In 1989 Florida, the fourth largest state by population, had only four such top research universities (UF, UM, USF and FSU), while California had 11, New York 9, Texas and Massachusetts 6 each. [NSF data.] This means that Florida not only has the job of building up its established research universities so that they are strong competitors within the top tier, but it has the additional job of strengthening other universities to enter the top tier. For our stature in research to match our population, Florida should have six of the top 100 research universities.

THE MISSIONS OF THE STATE UNIVERSITIES.

It is politically delicate to define the missions of the various state universities. Most do not want to rule out any sphere of activity. For the purposes of this proposal, however, we should indicate that five locations in Florida have been identified by the Chamber of Commerce study as having high potential for the development of local high-tech industry and it is these five locations upon which we want to concentrate.

UF and FSU obviously have state-wide roles, although both of them would also claim a role in local economic development through research parks and spin-off companies. USF has become the second largest university in the state, whether measured by students or research funding. Although its role in local economic development is apparent, it also rightfully claims a broad role in basic research of national significance. UCF, FAU and FIU are most obviously focused on research of significance to local industry.

Our proposal is not intended to forestall a major future role for UF and FSU in developing local industry, nor is it intended to prevent USF, UCF, FAU and FIU from developing as far as they can in the direction of basic research of national significance. And in the case of FAMU, UWF and UNF, our proposal is not meant to freeze them out of the research picture.

It is just not possible to satisfy all desires simultaneously and priorities have to be set. We view the creation or enhancement of Jobs Through Research Centers at the five locations as critical for the state's economic future. This should be supplemented by important statewide activities by UF and FSU directed toward improving high-tech related research through in-service education and super-computer services.

THE EDUCATIONAL ROLE OF THE UNIVERSITY OF FLORIDA.

The College of Engineering at the University of Florida is the largest in the state. It carries on extensive research in several areas, and it has centers providing educational services at various locations around the state. FEEDS (Florida Engineering Education Delivery System) provides long-distance courses to engineering professionals around the state.

Gainesville is not a manufacturing center, and is not likely to become one. Efforts by UF to establish an incubation center have been unsuccessful. However, UF already is heavily involved in providing many types of engineering training to professionals in industry: work toward advanced degrees; non-credit short-courses at Gainesville; training in centers around the state; and FEEDS. The total cost of this educational work is about $2

million per year. This is work of statewide significance which greatly assists high technology industry. UF's role is as a generalist, rather than as a specialist serving one particular local industry. UF can provide engineering education at a high level in areas where the local university might lack depth. UF can supplement the educational activities of the local universities.

As we develop a focus for the various areas of the state, engineering colleges will build up their strength in one specific area of local relevance. They will not try to be all things to all people. This makes sense. Small, young engineering colleges cannot hope to be excellent in all areas. UF, however, can fill in and serve an important transitional role.

RECOMMENDATION 1: (Not yet approved by the UFF Senate): THE STATE OF FLORIDA SHOULD INCREASE UF'S FUNDING FOR EDUCATING PROFESSIONALS EMPLOYED IN HIGH TECHNOLOGY INDUSTRY. THIS FUNDING SHOULD BE USED TO ESTABLISH MORE SHORT COURSES AT GAINESVILLE, MORE DISTANCE EDUCATION USING TELEVISION AND COMPUTERS, AND MORE OUTREACH CENTERS. WHENEVER POSSIBLE, UF SHALL COOPERATE WITH LOCAL STATE UNIVERSITIES IN DEVELOPING THE STRONGEST POSSIBLE EDUCATIONAL PROGRAM FOR LOCAL HIGH TECH PROFESSIONALS.

THE ROLE OF FSU'S SUPERCOMPUTING COMPUTATION CENTER.

FSU is the home of the Supercomputer Computations Research Institute (SCRI) which is a resource of statewide importance. This center can be of service to researchers throughout the state. Methods can be developed to integrate the center more closely with the needs of high tech industry.

At the present time, 65% of the computation time on the supercomputers at SCRI is taken up by the Department of Energy which has provided much of the funding for the Institute. If, however, the state was able to provide additional funding to link SCRI more closely with the needs of high-tech research in the various universities and companies throughin the state

SCRI has been extensively involved in computation for FSU's Center for Materials Research and Technology (MARTECH), specifically in researching the superconductive qualities of ceramic perovskites. SCRI has also been involved in computation for a Georgia Institute of Technology team working on the computerized simulation of the atomic qualities of materials and the consequences of these qualities for manufacturing processes. [FSU-SCRI.] During FY1990, research in materials science at SCRI concentrated on quantum systems, non-equilibrium phenomena and classical statistical mechanical systems. The quantum systems research relates to high temperature superconductors and magnetic materials. Non-equilibrium phenomena research relates to complex morphologies which occur during the processing of materials. And the classical statistical mechanical systems research relates to superconductors, molybdenum surfaces and electrochemical cells. All of this research has potential industrial significance. [FSU-SCRI-SAR-90.] This constructive beginning of SCRI's assistance to high-tech industry should be enhanced over the next few years.

RECOMMENDATION 2: (Not yet approved by the UFF Senate): THE STATE OF FLORIDA SHOULD INCREASE FSU'S FUNDING FOR THE SUPERCOMPUTING COMPUTATION CENTER. THIS FUNDING SHOULD BE USED TO INCREASE THE USE OF SUPERCOMPUTERS IN SUS RESEARCH, AS WELL AS TO

LINK THE CENTER MORE CLOSELY WITH THE NEEDS OF HIGH TECH INDUSTRY IN FLORIDA.

DEVELOPING HIGH TECHNOLOGY CLUSTERS.

The study written by SRI for the Florida Chamber of Commerce Foundation, **Enterprise Florida**, creatively charts the path which the state needs to follow over the next decade in developing new high technology industry. The study correctly emphasizes the need to develop new, indigenous companies, rather than relying on existing companies or attracting branch plants of large, out-of-state corporations.

Enterprise Florida identifies five emerging high technology cluster regions: lasers in Orlando; commercial uses of outer space around Melbourne; bio-medical technology in Miami; computers in Ft. Lauderdale and West Palm Beach; and a mixed group with emphasis on electronics and communications in Tampa and St. Petersburg. Each region has a mixture of branch plants of national corporations and locally headquartered corporations. Each emerging high technology cluster already has significant activity taking place in the private sector.

Of these clusters, only the laser industry in Orlando is already being adequately served by a university research center, CREOL at UCF. Each of the other clusters is not yet receiving the kind of support from university research centers which would be optimal. Jobs Through Research Centers will assist these four regions in achieving "critical mass" in the number of local scientists and engineers focusing on key problems of the industry and also in developing enough start-up companies to create a competitive entrepreneurial local culture within that industry.

Brevard County is already a technopolis, but more could be done to develop Florida-owned industry there. As of 1989, Brevard was the site of branches of the following firms: Harris with 11,000 employees; Lockheed, 5200; McDonnell Douglas, 3700; EG&G, 2000; Pan Am, 2000; Grumman, 1600; and RCA, 1400. [FCP-89.] Spaceport Florida is recruiting commercial space businesses and arranging for launch pads for private enterprise activities in space. In 1995, NASA is expected to launch a space station which will be the base for extensive commercial activity in space, such as growing perfectly shaped crystals in the absence of the strong pull of the earth's gravity. Over the next five years, some 34 commercial space launches are expected from the Kennedy Space Center. Commercial space divisions of General Dynamics, Martin Marietta, and McDonnell-Douglass, as well as a small, independent corporation, AstroTech, now employ almost a thousand people in Brevard, whereas almost none were employed in 1987. [FTYB-90.] We propose that a research center in the commercial uses of outer space be established in Brevard County under the auspices of the University of Central Florida. UCF's SERC may be the appropriate research center to carry this out.

In the Tampa-St. Petersburg area, nicknamed "Technology Bay", a concentration of electronics and communications equipment firms exists. Pinellas is the site of branches of: Honeywell (aerospatial avionics) with 4000 employees; AT&T Paradyne (data communication), 2500; and E-Systems ECI Division (military electronics), 2200. No large high-tech manufacturing plants exist in Hillsborough County, although IBM has a communications center there employing 1800. [FCP-89.] Some 236 high-tech firms were located in the region in 1986. Migrant entrepreneurs consider

this region the most attractive in the state because of its low housing costs and the availability of workers, including engineers. [**Enterprise Florida.**]

So far, this industry lacks a strong focus and the critical mass necessary for self-sustaining innovation in one specific industry. USF's research effort is increasing rapidly. In fiscal year 1988-89, research grants to the university were up 50% over the previous year. [**Closeup**, November, 1989.] However, total research funding at USF was lower in 1989-90 than in 1988-89 by almost $2 million. The problem is that state (especially Education, Transportation and HRS) funding was down by $6 million, while federal and private support were each up $2 million. [USF-DSR.] The growth in research funding at USF is strongest in medical areas. It is possible that some medical technology which links with the region's electronics and/or communications industry might be the most appropriate area for a high-tech related research center.

USF has also opened the first phase of its University Technology Center adjacent to the campus. This will eventually become an extensive research park with 1.2 million square feet of office and research space. [UTC.] What is needed for faster growth in the Technology Bay is a well-funded research center which will give focus to the scattered electronics and communications firms presently doing business there. .

In Dade County, the biotechnology industry is the most important area of high tech. Coulter Electronics is heavily involved in several medical technology fields. Viragen Inc. is engaging in research and development on treatments for cancer and viral diseases. And the medical school of the University of Miami is

carrying out $80 million R&D for medical equipment and biotechnology. This year the state appropriated $350,000 for a Center for Health Technologies at UM. [FTYB-90.] The UFF's "Jobs Through Research" program would enhance Dade's biomedical high tech industry with a research center at Florida International University which would concentrate on digital imaging devices, a specialty of FIU's College of Engineering already. Digital imaging is useful not only to Dade's medical technology industry, but also to the computer and communications industries in Broward and Palm Beach.

Related to this is the possibility that a research park and incubation center could be established at the Cordis building near FIU's University Park campus. The Cordis building is very large and quite empty, since Cordis drastically cut back their operations there. The Cordis site also has extensive grounds on which additional buildings could be constructed. If Dade County established a Research and Development Authority, similar to those in existence in other Florida counties, this site could be developed through the issuance of bonds and paid for out of the income of the research park.

In a section of Palm Beach and Broward counties known as "Silicon Beach", the computer industry has a foothold. Over half of all computer and communications jobs in Florida are located here. Palm Beach County was the site of plants of: Pratt & Whitney (aircraft engines) with 8000 employees; IBM, 5500; and Motorola (pagers), 1750. Broward had a Motorola plant employing 3500, a branch of Racal-Milgo, and a rare specimen, an indigenous Florida high-tech manufacturing plant, Encore Computer Products, employing 1500. [FCP-89.] The most famous computer operation is

that of IBM at Boca Raton, where the PC was developed, but several smaller companies are also active. This region has mainly been the location of branch plants of national corporations, with all of the disadvantages which this implies. [**Enterprise Florida**; Koenig.]

About 5000 jobs have been lost in high-tech industry in Broward-Palm Beach in the past three years. One of the core reasons for this loss is the absence of a major university-based research center. Local high-tech industrialists are strong supporters of a university-based research center of relevance to the local computer industry. [Koenig.] However, there is the potential in this two-county area for self-sustaining growth of locally-owned computer and communications firms, particularly if this industry could be given focus by a world-class research facility at Florida Atlantic University. This would give thrust to the research park which FAU is opening in the first quarter of 1991 and to the $3 million NASA grant FAU won to study high-definition television for the space station. [Koenig.]

RECOMMENDATION 3: THE STATE OF FLORIDA SHOULD UNDERTAKE A STRATEGIC DEVELOPMENT POLICY FOR SCIENCE AND ENGINEERING RESEARCH IN THE FIVE EMERGING HIGH TECHNOLOGY CLUSTERS IN THE STATE, AS IDENTIFIED IN THE FLORIDA CHAMBER OF COMMERCE STUDY, ENTERPRISE FLORIDA. SUFFICIENT FUNDS SHOULD BE ALLOCATED TO BUILD UP ONE UNIVERSITY RESEARCH CENTER OF NATIONAL STATURE (JOBS THROUGH RESEARCH CENTER) FOR EACH CLUSTER. GRADUATE STUDENTS SHOULD BE TRAINED AT EACH WHO ARE EQUIPPED WITH BOTH THE TECHNICAL KNOWLEDGE AND THE BUSINESS SKILLS TO START THEIR OWN HIGH TECH FIRMS, ALTHOUGH THE ACADEMIC INSTITUTIONS HAVE PRIMARY CONTROL OVER THE

EDUCATION OF STUDENTS IN SCIENCE AND ENGINEERING. THE JOBS THROUGH RESEARCH CENTER SHOULD ASSIST THESE START-UP FIRMS IN LOCATING SOURCES OF INVESTMENT CAPITAL AND BRINGING THEIR PRODUCTS TO MARKET.

ORGANIZING THE JOBS THROUGH RESEARCH CENTERS.

Finding an organizational structure for the Centers which takes into account the national research literature on effective university efforts to promote local high-tech industry and which also meets the concerns of university and industry people is difficult, but achievable. We want this effort to be successful and to accomplish two goals simultaneously: 1. To create world-class research centers which carry out important basic research; and 2. To create expanded opportunities for Floridians in high-tech industrial employment through locally-owned firms which spin off of university research and education.

Local firms should be consulted in an advisory fashion in planning the research thrust for the centers. The subject of inquiry should be broad enough to be significant to local firms, but narrow enough so that the center will have a real chance to become one of the top research institutions in the world in that area of study. Advisory boards should be established for each center which include representatives of local companies, and these outside advisors should be consulted on important changes of direction.

The physical facilities of the centers should include provisions for easy access by people coming to the campus from the outside. For instance, the centers should be located at the edge of the campus and have ample parking available so that busy industrialists and company researchers will not regard visiting the centers as too much of a hassle. If the centers are to do their job properly, they should be conducive to easy interchange

between the university researchers and people from the private sector. Lounges and offices should be furnished so as to make such visits pleasant.

In none of the regions are local universities giving enough support in terms of educating graduate students who can form start-up companies. In only one region (Orlando), is a sufficient effort being made to carry out research of significance to the particular industry. The State of Florida needs to capitalize on its advantages in these regions in order to maximize high tech growth. One important step would be to establish research centers at a public university in each region which would devote themselves both to educating graduate students (through the affiliated departmental structures) and to carrying out basic research. Prominent engineers and scientists should be hired to head these research centers, so that national grant funding can be secured. And excellent younger engineers and scientists should make up the larger part of the faculty of these centers.

The Centers should be world-class research institutions. They should be recognized around the world as being at the cutting edge of research in their discipline. They should employ internationally prominent researchers in leading positions, backed up by very able younger researchers. The prestige of the universities within the world of pure research should be enhanced by the Centers. The scientific and engineering communities should recognize that the Centers are carrying on valid basic research.

The top researchers in each Center should be given tenured lines in the university, with membership in an academic depart-

ment. They might teach an occasional graduate course, but their main function would be to carry out research at the Center. The Centers can be interdisciplinary, with faculty members from various departments participating. [Fusfeld.]

Professors from the "Jobs Through Research" Centers would be free, as are other university professors, to engage in paid consulting activities in private industry one day per week. In this manner, they could assist local firms with technical problems and carry out proprietary research. Any use of university laboratories, equipment and personnel in the carrying out of this research would be compensated by the companies. Professors would not be evaluated on this research by the Centers or their departments. Their time on these activities would be monitored, and they would be expected to devote 80% of their time to basic research and teaching on which they would be evaluated.

We are seriously interested in building world-class centers. We do not want simply to distribute state funding among existing professors in the universities. If existing professors do not have the research expertise or national credibility to develop a world-class center, new researchers should be hired who can do this. We do not want to spread the initial state funding widely around the university. If this program is to be successful, the CREOL model should be followed and the program should be tightly focused on a particular set of problems. We see this program as a lever for achieving a whole new level of funding and prestige for our universities. In the long run, everyone in the university will benefit from this, but in the short run the funding should be carefully targeted where it will do the most good.

An appropriate balance is necessary between university and corporate concerns. University people are worried that private

sector people will dictate the research agenda in a narrow fashion in accordance with the immediate goals of local corporations. They are afraid that this will prevent the Centers from doing basic research which will result in breakthroughs. Corporate leaders are worried that state funding will simply be used for the university's research agenda which will be impractical, of no use in developing new industry.

We recognize that both sets of fears are legitimate. We believe that appropriate legislation can be drafted which ensures a significant advisory role for high-tech industrialists in the operations of each Center: advisory, but not directing. Funding increases can be made conditional on the universities carrying out a research agenda which holds promise for benefiting the local economy. People with proven track records of relevant research and fundraising can be brought in as the leaders of the Centers.

Another set of concerns must be dealt with. People in several of the largest high-tech firms in Florida oppose the direction of the Centers toward new, start-up corporations. They prefer to concentrate on training engineers and scientists to enter their firms, and they want to have the universities work on research problems of interest to them. We believe that their interests can be partly served through a major expansion in graduate education for scientists and engineers in the five locations, as well as at UF and FSU. These Centers will employ faculty members who should be helpful to the existing corporations in research consultation. We expect existing firms to have an ongoing close relationship with the Centers which should be of considerable benefit to them. However, the main orienta-

tion of the Centers is to develop new, start-up companies and to create thousands of new, well-paying jobs for Floridians, and not to serve as props for existing high-tech companies which are mostly owned by out-of-state corporations and which mostly do not do their R&D work in Florida.

University and corporate people in areas of the state which are already well served by research centers oppose creating new research centers in areas of the state which are currently without adequate research strength in the state universities. We believe that all five areas have potential for high-tech industrial growth and that this growth is best assisted by research centers in the local public universities. These universities will develop in their research capacity as these research centers develop. They are not necessarily already strong as research institutions. Part of the purpose of Jobs Through Research is to help in the development of strong, research-oriented universities in all of the major population areas of the state. Locking the state's high-tech research thrust exclusively into statewide competitive proposals, such as the FHTIC grants, ensures that such strength will never be developed in state universities in locations such as Brevard, Broward-Palm Beach and Dade. This would be a waste of tremendous potential research strength and job creation.

People in private universities with research strength oppose putting resources into local public universities in their areas. We believe that the private universities will never receive state funding sufficient to develop world-class, high-technology-related research centers. Private universities do not appear to take seriously a mission to develop the local economy and to

create thousands of new jobs for local citizens. Only state universities can be relied upon to carry out this public policy. And even if the private universities did create such centers, it would only enhance the state's development if complementary high-tech research centers were also created in the local state universities. Also, private universities, as we have seen, cannot be relied upon in all cases to provide science and engineering educations for women and minority students. This failure would close off entrepreneurship opportunities for women and minorities in high-tech industry. Only state universities can be counted upon to advance affirmative action for women and minorities in such a prestigious and lucrative field as high-tech related research.

The basic research to be carried out by faculty members in the Centers will be of interest to the local high technology industry, but it will be public and free to all. The basic research will aim at extending the frontiers of knowledge in a manner which will be advantageous to local firms by giving them a technological edge due to propinquity. For instance, the researchers from the private firms will be in frequent oral communication with the university researchers and will thus be ahead of the rest of the world in understanding the implications of the new research, especially if they are helping to fund the university research. [Feller.]

The Centers should seek funding from federal and corporate sources. Nationally in 1985, corporations spent $485 million for R&D at universities, out of a $10 billion total university R&D budget. Corporations, then, represented only 5% of all university R&D expenditure in 1985. This rose to 8% in 1986. [Feller.]

It is important to understand that university research, in itself, is not likely to result in significant creation of new jobs in high technology industry. University researchers are properly concerned with advancing the general knowledge of humankind. They are generally more interested in basic research than in applied technology. They want to uncover the theoretical principles of how things work and share this knowledge with their colleagues around the world in public ways, whether at scholarly meetings or in research journals.

Not the professors, but rather the graduate students are the real vector by which universities spark the development of high tech clusters. Graduate students carry ideas from the university to the startup corporation. If we want to use universities to promote local high tech industry, then at least some graduate students should be imbued with an entrepreneurial spirit during their education. They should be given job experience in private industry while still in school. And they should be assisted by the university in developing, financing, manufacturing and marketing their ideas. The university, in turn, should have an equity share in their corporation and should benefit financially by their success.

We recognize that the core aspect of the graduate education of these students will be the particular science or engineering specialty. They will work closely with their professors on research topics of mutual interest. Students would earn their graduate degrees through the regular academic departments of the universities, but the Centers would bring them in contact with local high technology industry. The Centers would ensure that the students received the necessary training in business courses

and practical experience in order to start their own companies. The Centers would have enough resources to ensure that the normal tendency of academic departments to turn out pure researchers was not allowed to monopolize all of the graduate students. These students will not be in training to become professors, but to become entrepreneurs or researchers in high-tech companies.

We also recognize that these students will need start-up funding to take their innovative ideas into the marketplace. The Jobs Through Research Centers, incubation centers and research parks can assist in developing saleable products, building prototypes, and securing funding and marketing opportunities. Success in high-technology industry goes to those who devote their whole being to the enterprise. Students are young and vigorous enough to be successful. Over and over, high-tech companies have been built around young entrepreneurs.

In return for assisting students to beging in business, the universities would take an equity share in the start-up companies. From the profits accruing to the universities through this ownership share, various activities could be funded including: teaching and research assistantships for graduate students in programs related to the Centers; faculty research grants related to high technology research; assistantships, fellowships and scholarships across the university; and faculty research grants across the university.

What should be the role of professors in the Jobs Through Research Centers? Some professors across the country have involved themselves in the creation of new companies in genetic engineering. University research has been more productive of new knowledge for biotechnology firms than in-house corporate

research. University research produced four times as many patent application per dollar as corporate research. [Feller.] However, this is an exceptional situation. More normally, the university sticks to basic research and the corporation figures out how to take new ideas to market.

The potential for conflict of interest is very great when university research labs are being used in a for-profit enterprise. Universities should not be directly involved in owning corporations controlled by faculty members. The drive for profit should not control the direction of research. [Castells.] Professors should be mainly evaluated and rewarded by the universities on their teaching and their public research. Any involvement of professors in for-profit research should be restricted a specified number of hours per week and should not involve the expenditure of university funds, including lab facilities and materials.

To be sure, some professors will come up with successful products or processes in spite of these restrictions. Gatorade is the great Florida success story. Universities in Florida need new policies on patents so that professors will be encouraged to take their ideas to market with full assurance that they will be able to derive substantial financial benefit from doing so, while the universities should be assured of a fair share of the profits from ideas developed on university time and with university facilities. We do not want to create a situation where professors with marketable ideas will move to other universities with more favorable financial arrangements for patents. And we do not want them leaving the university for the private sector and taking with them ideas developed while employed at the university.

However, our main orientation toward professors should not be to expect them to come up with new patentable ideas, but rather to provide a high quality education for students and to carry out basic research in their chosen fields. Faculty salaries should be high enough so that professors are not faced with overwhelming financial pressure to go into private industry.

All kinds of shared research are possible between professors and high tech companies. However, it is not likely that the companies will turn their most crucial research over to professors. Proprietary secrets will be closely guarded. Protecting the confidentiality of in-house research is a very important consideration for high-tech corporate leaders in any shared activities with universities. [Rees, 1990.]

University professors are not good at working on the tight time deadlines characteristic of research in corporations. They are not paid to work round the clock. Universities should be on guard against their faculty members becoming merely hired guns for corporations. Scandals must be avoided by careful rules and monitoring. The rules governing the proper role for professors in private corporate research need to be adequately enforced. Universities can promote high technology industry while at the same time maintaining their own integrity as institutions primarily concerned with education and basic research. [Feller.]

Corporations are not mainly looking for commercial products from university research. Instead, they seek "[n]ew ideas, synergy between their research program and that of the university..." [Feller.] While 94% of 100 high-tech corporate leaders polled view in-house R&D as an important source of technical knowledge, 66% say universities are **unimportant** as a source

or no source at all. Nevertheless 60% of high-tech corporate leaders support state technology development programs, and 62% want such programs affiliated with universities. Their main concern with universities is course enrollment opportunities for their employees, followed by the use of faculty as consultants, the use of students as research assistants and interns, selling equipment to universities, and, finally, specific contractual research projects with universities. The main motive of those entering specific research projects is access to students as future employees, not product development. [Rees, 1990.]

The United Faculty of Florida opposes classified military research at public community colleges and universities in Florida. Faculty research should be public and available to the world. We encourage economic conversion of military-related high technology research to civilian purposes. We likewise encourage open and unclassified, rather than covert or classified, research.

Research parks and incubation centers can be a tool in moving ideas from the university laboratories to the marketplace. This is a tool which should be used with prudence. Far more space has been built across the country than there are high-tech firms to fill the space. [Fosler.] Research parks are not always successful in putting infant firms in contact with venture capital. They do not always help with marketing. They sometimes retain problem firms long after they should be eliminated. And they do not result always in successful startups and spinoffs. [Miller; Eisinger.]

Certainly, many successful research parks and incubation centers do exist. The Stanford Research Park, begun in 1951, was

important in the development of Silicon Valley. Low rent space was provided on university property to high-tech firms, including research facilities of national corporations. The university gave 99 year leases to companies locating there. With seven companies by 1955, the Research Park expanded to 90 companies with 25,000 employees by 1984. Stanford University earned substantial profits from its ownership of the park and was able to infuse these profits into its academic programs. [Castells; Gibson.]

In Florida, the experience with university-related research parks has been mixed. On the one hand, UCF's research park has been credited with attracting private sector industry. On the other hand, UF's research park seems to be going nowhere. [FT, November, 1987 and June, 1989.] New research parks are being established in Tampa and Boca Raton. At FIU, the opportunity to build a research park and incubation center may exist in connection with the largely empty Cordis building near the University Park campus.

Research parks are built either through tax-exempt bonds issued by a county research and development authority or through private funds raised by developers who have leased university land for the purpose. Direct state funds are not involved, although a government agency is issuing the bonds. Research parks are subsidized by the state, since the bonds are tax-exempt. Incubation centers appropriately receive state funding for their role in assisting new start-up companies, but research parks are generally entirely self-financing.

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